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Improving the cryosphere descriptions (snow and frozen soil) in a hydrologically improved land surface model

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As the primary components of the cryosphere, snow and frozen soil are critical for the research of the land surface process due to their wide distribution and distinct hydraulic and thermal properties. In this study, the cryosphere descriptions (snow and frozen soil) were significantly improved for the hydrologically improved Simple Biosphere Model 2 (HydroSiB2, Wang et al., 2009), to further extend its applicability to the Tibetan Plateau (TP). First, the three-layer snow module from WEB-DHM-S (the water and energy budget based distributed hydrological model with improved snow physics, Shrestha et al., 2010), has been incorporated into HydroSiB2 (hereafter HydroSiB2-S), to replace the original single-layer snow scheme. Secondly, a physically-based frozen soil scheme (Li and Sun, 2008) has been coupled with HydroSiB2-S (hereafter HydroSiB2-SF). The newly developed models were then rigorously evaluated at two typical sites over TP (one snowy and the other non-snowy, with both underlying frozen soil). At the snowy site in northeast TP (DY), HydroSiB2-SF demonstrated significant improvements over the model same as HydroSiB2-SF but with the original single-layer snow module by HydroSiB2 (hereafter HydroSiB2-F), showing the importance of multilayer snow parameterization in snowy regions. Meanwhile, at the non-snowy site in southwest TP (Ngari, extremely dry), HydroSiB2-SF gave reasonable simulations of soil temperature and liquid soil moisture during winter seasons while HydroSiB2-S did not, indicating the crucial role of frozen soil scheme in depicting the soil thermal and water dynamics.